42. $\Delta U = Q - W$
$Q = mc\Delta T = (300\ \text{kg})(0.11\ \text{kcal/kg}\cdot\text{C}^\circ)(-40^\circ)(4180\ \text{J/kcal}) = -5.52 \times 10^5\ \text{J}$
$Q = F\Delta\ell + mg\Delta\ell$
$\Delta\ell = \alpha\ell\Delta T = (11 \times 10^{-6}/\text{C}^\circ)(7.5\ \text{m})(-4\text{C}^\circ) = -3.3 \times 10^{-4}\ \text{m}$
$W = [3.8 \times 10^5\ \text{N}) + (300\ \text{kg})(9.8\ \text{m/s}^2)](-3.3 \times 10^{-14}\ \text{m}) = \underline{-125\ \text{J}}$
$\Delta U = -5.52 \times 10^5\ \text{J} - (-125\ \text{J}) = \underline{-5.52 \times 10^5\ \text{J}}$

43. (a) $e = 1 - T_1/T_2 = 1 - (253\ \text{K})/(293\ \text{K}) = 0.137$. Q_L, heat "wasted" is
$(0.6\ \text{kg})[(0.5\ \text{kcal/kg}\cdot{}^\circ\text{C})(20^\circ\text{C}) + (80\ \text{kcal}) + (1\ \text{kcal/kg}\cdot{}^\circ\text{C})(20^\circ\text{C})] = 66.0\ \text{kcal}.$
$W = Q_L\, e/(1 - e) = (10.4\ \text{kcal})(4180\ \text{J/kcal}) = \underline{4.4 \times 10^4\ \text{J}}.$

(b) In one second 200 W of the engine produces $(66\ \text{kcal})(200\ \text{J}/4.36 \times 10^4\ \text{J}) = 0.303\ \text{kcal}$ of "freezing."
Thus time is $(0.6\ \text{kg})[80(\text{kcal/kg}) + 1\ \text{kcal/kg}\cdot{}^\circ\text{C})(25^\circ\text{C})]/(0.303\ \text{kcal/s}) = 208\ \text{s}$ or $\underline{3.5\ \text{min}}$.

44. Heat wasted is
$Q_L = W(1/e - 1) = (750 \times 10^6\ \text{J/s})(1/0.4 - 1)$
$= 1.125 \times 10^9\ \text{J/s} = 1.125 \times 10^9\ \text{J/s} \times 1\ \text{cal}/4.18\ \text{J}$
$= 2.69 \times 10^8\ \text{cal/s}.$
Volume/time $= (2 \times 2.4 \times 10^{-3}\ \text{m}^3/\text{mol})(2.69 \times 10^8\ \text{cal/s})/(7.0\ \text{cal/molC}^\circ)(7.5\text{C}^\circ)]$
$= 2.46 \times 10^4\ \text{m}^3/\text{s} \times 8.64 \times 10^4\ \text{s/day} = 2.12 \times 10^9\ \text{m}^3/\text{d} = \underline{2.12\ \text{km}^3/\text{d}}$
<u>Yes</u>, this <u>will</u> affect the climate.
Area $= 2.12\ \text{km}^3/(0.2\ \text{km}) = \underline{10.6\ \text{km}^2}$

45. (a) $e = 1 - T_1/T_2 = 1 - (280\ \text{K})/(520\ \text{K}) = 0.462$
$Q_L/\text{time} = W(1/e - 1) = (900 \times 10^6\ \text{J/s})[1/(0.462) - 1] = 1.05 \times 10^9\ \text{J/s}$
$\Delta T = Q_L/mc = (1.05 \times 10^9\ \text{J/s})[(1000\ \text{kg/m}^3)(45\ \text{m}^3/\text{s})(4180\ \text{J/kg}\cdot\text{C}^\circ)] = \underline{5.6\text{C}^\circ}$

(b) $\Delta S/m = \Delta Q/mT$
$\Delta Q/m = c\Delta T = (1.000\ \text{kcal/kg}\cdot\text{C}^\circ)(5.58\text{C}^\circ)$
$= 5.58\ \text{kcal/kg}$
$\Delta S/m = (5.58\ \text{kcal/kg})/(280\ \text{k})$
$= 19.9\ \text{cal/kg}^\circ\text{K} \times (4.18\ \text{J/cal}) = \underline{83\ \text{J/kg}\cdot\text{K}}$

Chapter 16

1. The force is inverse square; so $F = (480 \times 10^{-3}\ N)/(1/8)^2 = \underline{31\ N}$.

2. Number is $(100 \times 10^{-6}\ C)/(1.60 \times 10^{-19}\ C) = \underline{6.25 \times 10^{14}}$ if we assume charge is negative.

3. $$F = \frac{(9 \times 10^9\ Nm^2/C^2)(26)(1.6 \times 10^{-19} C)^2}{(1.5 \times 10^{-12}\ m)^2}$$

$$F = \frac{9 \times 26 \times 1.6^2 \times 10^9 \times 10^{-38}}{2.25 \times 10^{-24}}\ N$$

$$F = \underline{2.7 \times 10^{-3}\ N}$$

4. $$2.0 \times 10^{-12}\ N = \frac{(9 \times 10^9\ Nm^2/C^{28})(1.6 \times 10^{-19}\ C)^2}{r^2}$$

$$r^2 = \frac{9 \times 10^9 \times 2.56 \times 10^{-38}}{2.0 \times 10^{-12}}\ m^2$$

$$r = \underline{1.07 \times 10^{-8}\ m}$$

5. $F = (9 \times 10^9\ N\ .\ m^2/C^2)(10^{-5}\ C)(3 \times 10^{-3}\ C)/(2\ m)^2 = \underline{68\ N}$.

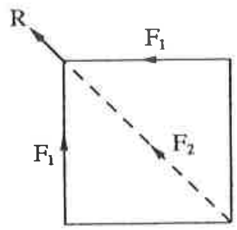
6. Water contains 10 protons and, as it is neutral, 10 electrons per molecule.
The number of molecules is $(1\ kg)/(18\ nucleons)(1.67 \times 10^{-27}\ kg/nucleon) = 3.33 \times 10^{25}$.
Hence total charge is $-(1.60 \times 10^{-19}\ C)(3.33 \times 10^{25})(10) = \underline{5.32 \times 10^7\ C}$.

7. $F_{12} = (9 \times 10^9)(70 \times 10^{-6})(48 \times 10^{-6})/(0.35)^2 = 246.9\ N$
$F_{13} = (9 \times 10^9)(70 \times 10^{-6})(80 \times 10^{-6})/(0.7)^2 = 102.9\ N$
$F_{23} = (9 \times 10^9)(48 \times 10^{-6})(80 \times 10^{-6})/(0.35)^2 = 282.1\ N$
$F_1 = -F_{12} + F_{13} = \underline{-114\ N\ (left)}$
$F_2 = F_{12} + F_{23} = \underline{+529\ N\ (right)}$
$F_3 = -F_{13} - F_{23} = \underline{-385\ N\ (left)}$

8. Any two repel the third with forces, magnitude equal to

$$\frac{(9 \times 10^9\ N \cdot m^2/C^2)(7 \times 10^{-6} C)^2}{(0.2\ m)^2} = 11.025\ N$$

The force by symmetry bisects the angle and equals
$2 \times 11.025\ N \cos 30^\circ = \underline{19.1\ N}$

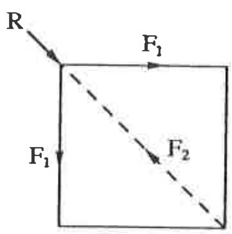
9. 

In magnitude $F_1 = \dfrac{(9 \times 10^9\ \mathrm{N \cdot m^2/C^2})(5 \times 10^{-3}\mathrm{C})^2}{(0.75\ \mathrm{m})^2} = 4 \times 10^5$ N.

$F_2 = \dfrac{(9 \times 10^9\ \mathrm{N \cdot m^2/C^2})(5 \times 10^{-3}\mathrm{C})^2}{(0.75^2 + 0.75^2)} = 2 \times 10^5$ N

Resolving in direction of F_2, resultant is
$F_2 + 2F_1 \cos 45^\circ = \underline{7.7 \times 10^5\ \mathrm{N}}$
There are similar results for other charges.

10. Use F_1 and F_2 from Problem 9
$R = 2F_1 \cos 45^\circ - F_2 = \underline{3.66 \times 10^5\ \mathrm{N}}$



11. (a) $Q_1 = Q_2 = Q_T/2$, as determined by calculus

(b) $Q_1 = \underline{0}$, $Q_2 = \underline{Q_T}$

12. Place charge distance x beyond $-2.3\ \mu$C charge on extension of the line joining the 3.8 μC and $-2.3\ \mu$C charges. Then attractive force $\dfrac{K(2.3\ \mu C)Q}{x^2}$ balances repulsive force $\dfrac{K(3.8\ \mu C)\,Q}{(x + 0.18\ \mathrm{m})^2}$.

Solving gives $x = \underline{0.63\ \mathrm{m}}$

13. $Q_1Q_2 = r^2F/k = (1.2\text{ m})^2(12.0\text{ N})/(9 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2) = 1.92 \times 10^{-9}\text{C}^2$
$Q_1 + Q_2 = 90 \times 10^{-6}\text{ C}$
$Q_1 + (1.92 \times 10^{-9})/Q_1 = 90 \times 10^{-6}$
$Q_1^2 - 90 \times 10^{-6}\, Q_1 + 1.92 \times 10^{-9} = 0$
$Q_1 = 5.52 \times 10^{-5}\text{ C},\ 3.48 \times 10^{-5}\text{ C}$
These are the values for Q_1 and Q_2 ($\underline{55.2\ \mu\text{C},\ 34.8\ \mu\text{C}}$)
If repulsive, then $Q_1Q_2 = -1.92 \times 10^{-9}\text{ C}^2$
$Q_1^2 - 90 \times 10^{-6}\, Q_1 - 1.92 \times 10^{-5} = 0$
$Q = 1.078 \times 10^{-4}\text{ C},\ -1.78 \times 10^{-5}\text{ C}$
So Q_1 and Q_2 are $\underline{107.8\ \mu\text{C}}$ and $\underline{-17.8\ \mu\text{C}}$

14. $F = qE = (-1.6 \times 10^{-19}\text{ C})(800\text{ N/C}) = \underline{-1.28 \times 10^{-16}\text{ N}}$, opposite to direction of E field.

15. $E = \dfrac{F}{q} = \dfrac{3.4\text{ N}}{-2.8 \times 10^{-6}\text{ C}} = \underline{-1.2 \times 10^6\text{ N/C}}$

E field is opposite to Force, i.e. up.

16. $E = \dfrac{F}{q} = \dfrac{4 \times 10^{-16}\text{ N}}{-1.6 \times 10^{-19}\text{ C}} = \underline{-2500\text{ N/C}}$

E field is opposite to Force.

17. $E = \dfrac{KQ}{r^2} = \dfrac{(9 \times 10^9\text{ N m}^2/\text{C}^2)}{(0.1\text{ m})^2}(28 \times 10^{-6}\text{ C}) = \underline{2.52 \times 10^7\text{ N/C, up}}$

18. $E = (9 \times 10^9\text{ N m}^2/\text{C}^2)\left[\left[\dfrac{8 \times 10^{-6}\text{ C}}{(0.02\text{ m})^2}\right] + \left[\dfrac{6 \times 10^{-6}\text{ C}}{(0.02\text{ m})^2}\right]\right] = 9 \times 10^9[2 \times 10^{-2} + 1.5 \times 10^{-2}]$
$= 9 \times 10^9 \times 3.5 \times 10^{-2}\text{ N/C} = 3.15 \times 10^8\text{ N/C}$
The field is towards the $-8.0\ \mu\text{C}$ charge, because the $-8\ \mu\text{C}$ is attractive, the $6\ \mu\text{C}$ charge is repulsive.
$E = \underline{3.15 \times 10^8\text{ N/C}}$.

19. At A the two x components cancel and the y component (up) must be calculated from $2\ E \sin \theta$, where $\theta = \arctan (5\text{ cm}/10\text{ cm}) = 26.6^\circ$.
Then $E = 2(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2(\sin 26.6^\circ)(4 \times 10^{-6}\ \text{C})/(0.05^2 + 0.10^2)\text{m}^2 = \underline{2.58 \times 10^6\ \text{N/C up}}$.
At B the nearest charge is on a line $\theta_1 = 45^\circ$ and the farthest charge is on a line $\theta_2 = \arctan (5\text{ cm}/15\text{ cm}) = 18.4^\circ$.
Thus $E_x = E_1 \cos 45^\circ - E_2 \cos 18.4^\circ$
$= (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(4 \times 10^{-6}\ \text{C})[(\cos 45^\circ)/(0.05^2 + 0.05^2)\text{m}^2 - (\cos 18.4^\circ)/(0.05^2 + 0.15^2)\text{m}^2]$
$= 3.72 \times 10^6$ N/C.
And $E_y = E_1 \sin 45^\circ + E_2 \sin 18.4^\circ$
$= (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(4 \times 10^{-6}\ \text{C})[(\sin 45^\circ)/(0.05^2 + 0.05^2)\text{m}^2 + (\sin 18.4^\circ)/(0.05^2 + 0.15^2)\text{m}^2]$
$= 5.55 \times 10^6$ N/C.
Hence $E = \underline{6.7 \times 10^6\ \text{N/C}}$ at an angle to the right of $\underline{56.2^\circ}$. This is consistent with the figure.

20. The resultant electric field is due only to the 38 μC and -24 μC charges on the same diagonal as the other field cancels.

$$E = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\left[\frac{(38 \times 10^{-6}\ \text{C}}{\frac{(0.35)^2}{2}\text{m}^2} + \frac{24 \times 10^{-6}\ \text{C}}{\frac{(0.35)^2}{2}\text{m}^2}\right]$$

$= \underline{9.11 \times 10^6\ \text{N/C}}$ on diagonal $\underline{\text{away from 38 }\mu\text{C}}$.

21. If the E field from the two nearest corners is E_1 and from the diagonal corner is E_2, then $E = 2E_1 \cos 45^\circ + E_2$.

$$= (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(250 \times 10^{-7}\ \text{C})\left[\left[\frac{2 \cos 45^\circ}{(0.5\ \text{m})^2}\right] + \frac{1}{(0.05^2 + 0.5^2)\text{m}^2}\right]$$

$= \underline{1.7 \times 10^6\ \text{N/C away from center}}$

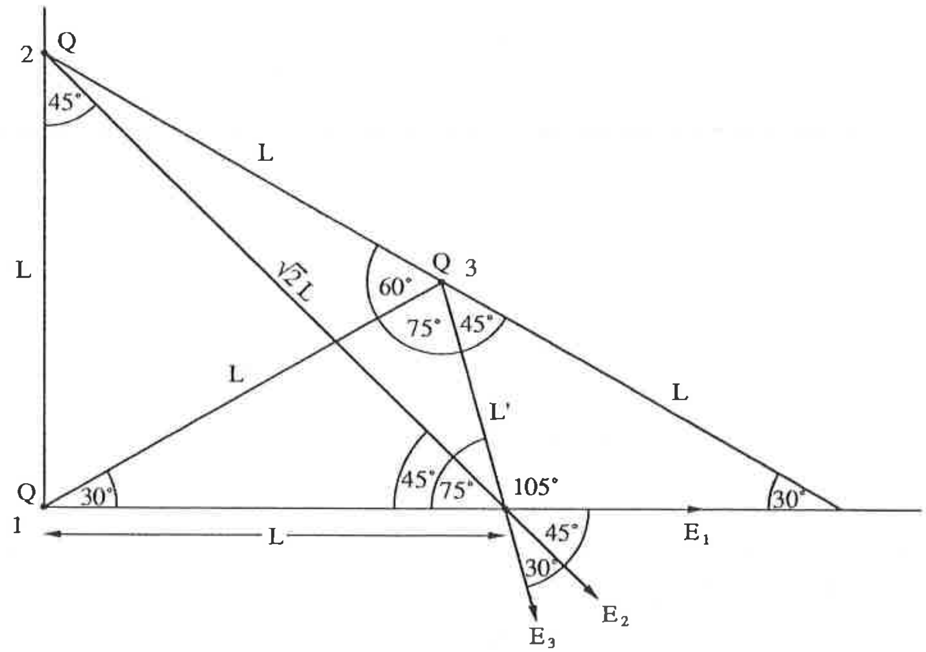
22. $$a = \frac{Eq}{m} = \frac{-(3500\ \text{N/C})(1.6 \times 10^{-19}\ \text{C})}{9.11 \times 10^{-31}\ \text{kg}}$$

$= \underline{-6.15 \times 10^{14}\ \text{m/s}^2}$
i.e. $\underline{\text{opposite to applied field}}$.

23\. (a) By symmetry, $E = 0$ at the centroid since E_O, E_A, E_B form an equilateral triangle (and t ave zero sum).

Hence $(x,y) = (\ell \cos 30°/3, (\ell + \ell/2)/3)$
$= (0.289\ell, 0.5\ell)$.

(b)



$$L' = 2L \cos 75°$$

$$E_{1x} = \frac{kQ}{L^2} \qquad E_{1y} = 0$$

$$E_{2x} = \frac{kQ}{2L^2}\cos 45 \qquad E_{2y} = \frac{-kQ}{2L^2}\sin 45$$

$$E_{3x} = \frac{kQ\cos 75}{(2L\cos 75)^2} \qquad E_{3y} = \frac{-kQ\sin 75}{(2L\cos 75)^2}.$$

$$E_x = \frac{kQ}{L^2}\left[1 + \frac{\cos 45}{2} + \frac{\cos 75}{(2\cos 75)^2}\right] = \frac{2.32\,kQ}{L^2}.$$

$$E_y = \frac{kQ}{L^2}\left[\frac{-\sin 45}{2} - \frac{\sin 75}{(2\cos 75)^2}\right] = \frac{3.96\,kQ}{L^2}.$$

$$E = \sqrt{E_x^2 + E_y^2} = \frac{4.49\,kQ}{L^2}.$$

$$\tan\theta = \frac{3.96}{2.32}, \quad \theta = \underline{-59.6°}$$

(a) $E_{1y} = \frac{-kQ}{L^2}$ $\qquad E_{1x} = 0$

$E_{2x} = \frac{-kQ}{L^2} \cos 60 \qquad E_{2y} = \frac{-kQ}{L^2} \sin 60$

$E_x = -\frac{\sqrt{3}}{2}\frac{kQ}{L^2}, \qquad E_y = -1.5\frac{kQ}{L^2}.$

$E = \sqrt{E_x^2 + E_y^2}$

$E = \underline{1.73\frac{kQ}{L^2}}$ at $\underline{-120°}$

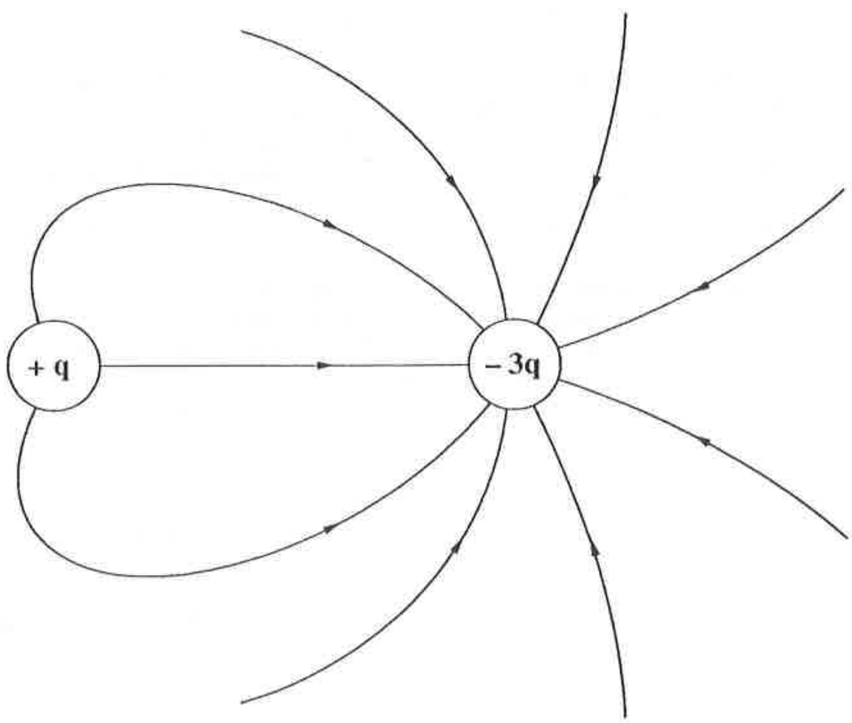
$E_x = +\frac{kQ}{L^2} \cos 30° = +0.866\ kQ/L^2$

$E_y = \frac{kQ}{L^2}(-1 + \sin 30°) = -0.5\ kQ/L^2$

$E = [E_x^2 + E_y^2]^{\frac{1}{2}} = \underline{kQ/L}$

$\theta = \text{arc tan}\ (-0.5/0.866) = \underline{-30°}$

25.



26. $$E = \frac{ma}{Q} = \frac{(1.67 \times 10^{-27}\ \text{kg})(9.8\ \times 10^{4}\ \text{m/s}^2)}{1.6 \times 10^{-19}\ \text{C}}$$

$= \underline{1.02 \times 10^{-3}\ \text{N/C}}$.

27. Let $d(km)$ be distance from center of earth.
Then $m_E/d^2 = (m_E/81)/(3.80 \times 10^5 - d)^2$, i.e. $9(3.80 \times 10^5 - d) = d$.
Hence $d = (9/10)(3.80 \times 10^5\ \text{km}) = \underline{3.42 \times 10^5\ \text{km}}$.

28. (a) $a = \frac{EQ}{m} = \frac{(3.0 \times 10^4\ \text{N/C})(1.6 \times 10^{-19}\ \text{C})}{9.11 \times 10^{-31}\ \text{kg}} = 5.27 \times 10^{15}\ \text{m/s}^2$

$v = (295)^{\frac{1}{2}} = [2 \times (5.27 \times 10^{15}\ \text{m/s}^2) \times (1.6 \times 10^{-2}\ \text{m})]^{\frac{1}{2}} = \underline{1.30 \times 10^7\ \text{m/s}}$

(b) Gravity gives g much smaller than a.

29. (a) There are 14 atoms on the Thyamine and 14 on the Adenine. This gives 14×14 pairs of forces to find and resolve. If we position each atom at (x_t, y_t) and (x_a, y_a) then we find the X component of the force to be a sum over all t and a $\Sigma(x_a - x_t)/[(x_a - x_t)^2 + (y_a - y_t)^2]^{3/2}$ and the Y component is $\Sigma(y_a - y_t)/[(x_a - x_t)^2 + (y_a - y_t)^2]^{3/2}$. The sums can be performed using a computer. To estimate the force begin with "nearest neighbors," i.e. O–H bond and N–H bond.
$F_{OH} = ke^2(0.4)(0.2)/(1.8 \times 10^{-10}\ \text{m})^2$. And $F_{NH} = ke^2(0.2)(0.2)/(1.8 \times 10^{-10}\ \text{m})^2$.
Each force is attractive. $F_{OH} = 5.69 \times 10^{-10}$ N. $F_{NH} = 2.84 \times 10^{-10}$ N.
The next most important forces are due to the repulsion of the NN and ON atoms.
$F_{NN} = 1.03 \times 10^{-10}$ N. $F_{ON} = 2.35 \times 10^{-10}$ N.
Taking these forces as all approximately parallel gives $F = \underline{5.15 \times 10^{-10}\ \text{N}}$. To estimate the error in this result note that the two H atoms are about $[(0.8A^\circ)^2 + (1.73A^\circ)^2]^{\frac{1}{2}} = 1.91 \times 10^{-10}$ m.
This gives a force of repulsion perpendicular to that already calculated of
$[k(0.2\ e)^2/(1.91 \times 10^{-10}\ \text{m})^2] \sin \arctan(0.8/1.73) = \underline{2.21 \times 10^{-10}\ \text{N}}$ and a further repulsion of 1.22×10^{-10} N. Thus we now estimate a force of attraction along the line of centers of about $\underline{3.93 \times 10^{-10}\ \text{N}} \approx 4 \times 10^{-10}$ N. Clearly the convergence is quite poor. In practice a potential curve would be found and differentiated to find the force.

(b) If we just take $F = 2, F_{HO} - 2F_{NO} + F_{NH} - F_{NN}$ we estimate
$F = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.6 \times 10^{-19}\ \text{C})^2[2(0.2)(0.4)/(1.9)^2 - 2(0.2)(0.4)/(2.90)^2$
$+ (0.2)(0.2)/(2)^2 - (0.2)(0.2)/(3)^2]/(10^{-10}\ \text{m})^2 = \underline{7 \times 10^{-10}\ \text{N}}$.

(c) Hence total force is about $10^5(7.10 \times 10^{-10}\ \text{N} + 3.93 \times 10^{-10}\ \text{N})/2 \simeq \underline{5.5 \times 10^{-5}\ \text{N}} \approx 10^{-4}$ N.

30. $r = e(k/mg)^{\frac{1}{2}} = (1.6 \times 10^{-19}\ \text{C})(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)^{\frac{1}{2}}/[(9.11 \times 10^{-31}\ \text{kg})/(9.8\ \text{m/s}^2)]^{\frac{1}{2}} = \underline{5.08\ \text{m}}$.

31. Copper has 29 electrons per atom.
Each atom has mass 63.7 amu.
Therefore, for 3×10^{-3} kg of neutral copper, we normally have
$(3 \times 10^{-3}\ \text{kg})(29)/(63.7)/(1.66 \times 10^{-27}\ \text{kg}) = 8.23 \times 10^{23}$ electrons.
The number lost $(80 \times 10^{-6}\ \text{C})/(1.6 \times 10^{-19}\ \text{C}) = 5 \times 10^{14}$.
Hence f = lost/normal = $\underline{6.1 \times 10^{-10}}$.

32. $E = mg/Q = (1.67 \times 10^{-27}\ \text{kg})(9.8\ \text{m/s}^2)/(1.60 \times 10^{-9}\ \text{C}) = \underline{1.02 \times 10^{-17}\ \text{N/C up}}$.

33. $Q = ER^2/k = (150\ \text{N/C})(6.38 \times 10^6\ \text{m})^2/(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2) = \underline{6.8 \times 10^5\ \text{C}}$. The charge is <u>negative</u>.

34. If the field is zero, there is no force on a test charge. Either both Q_1 and Q_2 are negative or both Q_1 and Q_2 are positive. Further to balance $kQ_1/(d/3)^2 = kQ_2/(2\ d/3)^2$, i.e. $Q_1 = \underline{Q_2/4}$.

35. Let E fields due to 1, 2, 3, 4 charges be E_1, E_2, E_3, E_4.
Let 12 side be x axis, and 14 side be y axis. Then
$E_x = (E_1 - E_2 - E_3 + E_4) \cos 45°$ and
$E_y = (E_1 + E_2 - E_3 - E_4) \cos 45° \Rightarrow E_x = 0$
$E_y = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(10^{-6}\ \text{C})(1 + 2 - 3 - 4)(\cos 45°)/(0.2^2\ \text{m}/2)$
$= \underline{1.3 \times 10^6\ \text{N/C, i.e. parallel to 41 side}}$

36. $F = [(9 \times 10^9)(0.4)(0.2)(1.6 \times 10^{-19})^2/(10^{-9})^2][+0.3^{-2} - 0.4^{-2} - 0.18^{-2} + 0.28^{-2}]$
$= \underline{-2.44 \times 10^{-10}\ \text{N, attractive}}$

37. $mg = EQ = ENe$, i.e. $N = (4\pi/3)(0.02 \times 10^{-3}\ \text{m})^3(1000\ \text{kg/m}^3)(9.8\ \text{m/s}^2)/(150\ \text{N/C})/(1.60 \times 10^{-19}\ \text{C})$
$= \underline{1.4 \times 10^7}$.

38. $Fe = \dfrac{mv^2}{r} \Rightarrow \dfrac{kq^2}{r^2} = \dfrac{mv^2}{r}$

$$r = \frac{kq^2}{mv^2}.$$

$$r = \frac{(9 \times 10^9)(1.6 \times 10^{-19})^2}{(9.11 \times 10^{-31})(1.1 \times 10^6)^2} = \underline{2.09 \times 10^{-10}\ \text{m}}.$$

39. As two charges repel one another along the line joining them the charge must be on this line. must be fixed. Then assuming a distance $f\ell$ from $-Q_0$ a positive charge Q will attract and balai the repulsive force $F = 3\ kQ_0^2/\ell^2$ if $f = (Q/3Q_0)^{1/2}$.
For the $-3Q_0$ charge we must have $(1 - f) = (Q/Q_0)^{1/2}$.
Eliminating f, $Q = Q_0/[1 + 1/(3)^{1/2}]^2 = \underline{0.402\ Q_0}$; $f = \underline{0.366}$.

40. Consider forces on balls.

$$T \sin 30 = \frac{kq^2}{(2x)^2}.$$

$$T \cos 30 = (0.028)(9.8).$$

$$\tan 30 = \frac{kq^2}{(4x^2)(0.028)(9.8)}$$

$x = (0.70\ \text{m}) \sin 30 = 0.35$ m.

$$q^2 = \frac{4 \times 0.35\ \text{m}^2 \times (0.028 \times 9.8\ \text{m/2})\tan 30}{9 \times 10^9}$$

$q = 2.94 \times 10^{-6}$ C
Change of electroscope $= 2q$.
$= \underline{5.87\ \mu\text{C}}$.

41. (a) $$a = \frac{qE}{m} = \frac{-(8.4 \times 10^3\ \text{N/C})(1.6 \times 10^{-19}\ \text{C})}{9.11 \times 10^{-31}\ \text{kg}} = -1.475 \times 10^{15}\ \text{m/s}^2$$

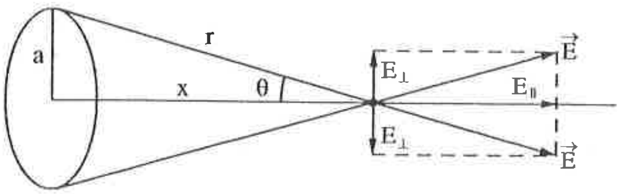
$$d = \frac{v^2 - u^2}{2a} = \frac{0 - (2.4 \times 10^6\ \text{m/s})^2}{2(-1.475 \times 10^{15}\ \text{m/s}^2)} = \underline{1.9 \times 10^{-3}\ \text{m}}$$

(b) From start to where it stops,

$$t = \frac{v - u}{a} = \frac{0 - 2.4 \times 10^6\ \text{m/s}}{-1.475 \times 10^{15}\ \text{m/s}^2} = 1.627 \times 10^{-9}\ \text{s}$$

Time elapsed for it to return to starting point is $2t$ which is $\underline{3.2 \times 10^{-9}\ \text{s}}$.

42.



$\tan\theta = a/x$, $r = (x^2 + a^2)^{\frac{1}{2}}$

The electric field will be along the axis, since all parallel components will add, but components perpendicular to the axis from opposite sides of the ring will cancel.

Let $\Delta\ell$ be the length of a small segment.

Total length is $2\pi a$.

Charge on $\Delta\ell$ is $\Delta Q = Q(\Delta\ell/2\pi a)$

Due to $\Delta\ell$,

$\Delta E_{\parallel} = (k\Delta Q/r^2)\cos\theta = (kQ\Delta\ell/2\pi a)/r^2](x/r)$

$\Delta E_{\parallel} = (kQx/r^3)(\Delta\ell/2\pi a)$

Summing up $\Delta E_{\parallel}$ means summing up $\Delta\ell$.

But $\Sigma\Delta\ell = 2\pi a$

So,

$$E_{\parallel} = kQx/r^3(2\pi a/2\pi a) = kQx/r^3$$

$$E = \frac{1}{4\pi E_0}\frac{Qx}{(x^2 + a^2)^{3/2}}$$

E is along the axis, away from the ring.

Chapter 17

1. $W = q\Delta V = (-8.0 \times 10^{-6}\ C)(75\ V - 0\ V) = \underline{-6.0 \times 10^{-4}\ J}$.
Here the negative sign indicates that the charge move <u>creates energy</u>.

2. Notice an electron is negatively charged, so it "falls" up a potential gradient.
$KE = (-1.60 \times 10^{-19}\ C)(-350\ V) = \underline{5.6 \times 10^{-17}\ J}$.

3. $\Delta V = E_K/e = (4.2 \times 10^{-16}\ J)/(-1.6 \times 10^{-19}\ C) = \underline{-2.63\ kV}$
The electron "falls" up from low to high potential so <u>B has higher potential</u>.

4. $E = V/d$
$d = V/E = (24\ V)/(600\ V/m) = \underline{4.0\ cm}$

5. $E = V/d = 170\ V/(0.006\ m) = \underline{2.83 \times 10^4\ V/m}$

6. $V = Ed = (800\ V/m)(.016\ m) = \underline{12.8\ V}$

7. $W = KE = qV$
$38keV = (2e)V$
$V = 19\ kV$

8. Work done overcoming the potential was $18.0 \times 10^{-4}\ J - 4.0 \times 10^{-4}\ J = 14.0 \times 10^{-4}\ J$
$V = W/q = (14.0 \times 10^{-4}\ J)/(-3.0 \times 10^{-6}\ C) = \underline{-467\ V}$
$\underline{V_a > V_b}$

9. $(950\ eV)(1.6 \times 10^{-19}\ J/eV) = (9.11 \times 10^{-31}\ kg)v^2/2$
$v = \underline{1.83 \times 10^7\ m/s}$

10. $(20 \times 10^6\ eV)(1.6 \times 10^{-19}\ J/eV) = (1.67 \times 10^{-27}\ kg)v^2/2$
$v = \underline{6.19 \times 10^7\ m/s}$

11. $V = kQ/r = (9 \times 10^9\ N \cdot m^2/C^2)(4.85 \times 10^{-6}\ C)/(0.21\ m) = \underline{2.08 \times 10^5\ V}$

12. (a) $V = kQ/r = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.6 \times 10^{-19}\ \text{C})/(0.53 \times 10^{-10}\ \text{m}) = \underline{27.2\ \text{V}}$

(b) $PE = qV = (-e)(27.2\ \text{V}) = -27.2\ \text{eV} = \underline{-4.35 \times 10^{-18}\ \text{J}}$

13. Voltage at midpoint is V_a
$V_a = 2(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(30 \times 10^{-6}\ \text{C})/(0.30\ \text{m}) = 1.8 \times 10^6\ \text{N}$
Voltage at new position is
$V_b = (9 \times 10\ \text{N}\cdot\text{m}^2/\text{C}^2)(30 \times 10^{-6}\ \text{C})[1/(0.20\ \text{m}) + 1/(0.40\ \text{m})] = 2.025 \times 10^6\ \text{V}$
$\Delta V = V_b - V_a = 2.25 \times 10^5\ \text{V}$
work $= Q\Delta V = (.20 \times 10^{-6}\ \text{C})(2.25 \times 10^5\ \text{V}) = \underline{0.045\ \text{J}}$

14. To bring up first electron costs no energy. To bring up second costs ke^2/r.
To bring up third costs $QV = e\ 2\ ke/r = 2\ ke^2/r$.
Thus $W = 3\ ke^2/r = (3)(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.6 \times 10^{-19}\ \text{C})^2/(10^{-10}\ \text{m}) = \underline{6.9 \times 10^{-18}\ \text{J}}$.

15. (a) $V_b - V_a = kq\left[\frac{1}{b} - \frac{1}{a}\right] = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(-2.8 \times 10^{-6}\ \text{C})\left[\frac{1}{0.8} - \frac{1}{0.65}\right] = 7.27 \times 10^3\ \text{V}$

(b) E_b is east and has magnitude $\frac{kQ}{b^2} = \frac{(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(2.8 \times 10^{-6}\ \text{C})}{(0.8\ \text{m})^2} = 39375\ \text{N/C}$

E_a is south and has magnitude $= \frac{(9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(2.8 \times 10^{-6}\ \text{C})}{(0.65\ \text{m})^2} = 59645\ \text{N/C}$

$E_b - E_a$ has magnitude $\underline{71470\ \text{N/C}}$ and points $\underline{56.6^\circ\ \text{N of E}}$.

16. $V_B = \frac{-kq}{b} + \frac{kq}{(d-b)}$

$V_A = \frac{kq}{b} - \frac{kq}{(d-b)}$

$V_B - V_A = \frac{kq}{d-b} - kq/b - kq/b + \frac{kq}{(d-b)}$

$V_B - V_A = \frac{2kq}{(d-b)} + \frac{2kq}{b} = 2kq[1/(d-b) + 1/b]$

17. (a) $Qd = (1.6 \times 10^{-19})(0.53 \times 10^{-10}\ \text{m}) = \underline{8.48 \times 10^{-30}\ \text{C}\cdot\text{m}}$.

(b) The electrical potential function, which varies inversely as the square of the distance, is zero, as for every $\cos\theta$, there will be a $\cos(\theta + \pi)$ or $-\cos\theta$ term. In this sense we say the average dipole moment is zero.

18. $V = kQ\ell \cos\theta/r^2 = (9 \times 10^9\ \mathrm{N\cdot m^2/C^2})(4.8 \times 10^{-30}\ \mathrm{C\cdot m})\cos\theta/(10^{-9}\ \mathrm{m})^2 = 0.0432 \cos\theta\ V$.
If θ is zero this corresponds to being nearest to positive charge, that is why V is positive. Thus

(a) 0.0432 V

(b) 0.0432 (cos 45°)V = 0.0305 V

(c) θ = 135°.

Voltage is − 0.0305 V.

19. (a) $V_{real} = (9 \times 10^9\ \mathrm{N\cdot m^2/C^2})(6.6 \times 10^{-20}\ \mathrm{C})[-1/(9 \times 10^{-10}\ \mathrm{m}) + 1/(9 \times 1.2) \times 10^{-10}\ \mathrm{m}] = -0.078\ \mathrm{V}$

(b) Percent error is $(V_{real} - V_{dipole})/V_{real} = 0.133 \times 100\% = 13.3\%$

20. $p = 2p_1 \cos 52°$.
Hence $p_1 = 4.95 \times 10^{-30}\ \mathrm{C\cdot m} = Q\ell$.
Hence $Q = (4.95 \times 10^{-30}\ \mathrm{C\cdot m})/(0.96 \times 10^{-10}\ \mathrm{m}) = 0.516 \times 10^{-19}\ \mathrm{C}$.

21. $PE = \Sigma QV = -Qkp_1/r^2 + Qkp_1(r + \ell)^2 \simeq Qkp_1(-2\ell/r)/(r)^2$
using the binomial expansion $(r + \ell)^{-2} \simeq (1 - 2\ell/r)r^{-2}$.
Thus $PE = -2kp_1p_2/r^3$, where $p_2 = Q\ell$.

22. $Q = VC$, $C = Q/V = (2500 \times 10^{-6}\ \mathrm{C})/(888\ \mathrm{V}) = 2.82\ \mu\mathrm{F}$

23. $C = Q/V = (65 \times 10^{-12}\ \mathrm{C})/(20\ \mathrm{V}) = 3.25\ \mathrm{pF}$

24. $V = Q/C = (18.0 \times 10^{-8}\ \mathrm{C})/(12{,}000 \times 10^{-12}\ \mathrm{F}) = 15\ \mathrm{V}$

25. $Q = VC = (12\ \mathrm{V})(7.5 \times 10^{-6}\ \mathrm{F}) = 90\ \mu\mathrm{C}$

26. $A = Cd/\varepsilon_0 = (1\ \mathrm{F})(0.0060\ \mathrm{m})/(8.85 \times 10^{-12}\ \mathrm{C^2/N\cdot m^2}) = 6.78 \times 10^8\ \mathrm{m}^7$
We neglect the difference between vacuum and air.

27. $C = \varepsilon_0 kA/d = (8.85 \times 10^{-12}\ \mathrm{C^2/N\cdot m^2})(2.2)(0.16\ \mathrm{m})^2/(0.0023\ \mathrm{m}) = 217\ \mathrm{pF}$

28. $Q = CV$

$\Delta Q = C\Delta V$

$C = \Delta Q/\Delta V = (16 \times 10^{-6}\ \text{C})/(40\ V - 28\ V) = \underline{1.33\ \mu\text{F}}$

29. $Q = CV = (\varepsilon_0 A/d)V = \varepsilon_0 AV/d$

$= (8.85 \times 10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)(120 \times 10^{-4}\ \text{m}^2)(28 \times 10^6\ \text{V/m})/(0.020\ \text{m}) = \underline{1.49 \times 10^{-4}\ \text{C}}$

30. $E = V/d = (Q/C)/d = Q/Cd = (800 \times 10^{-6}\ \text{C})/[(30 \times 10^{-6}\ \text{F})(0.0030\ \text{m})] = \underline{8.89 \times 10^3\ \text{N/C}}$

31. $Q = CV = (5.5\ \mu\text{F})(25\ \text{V}) = 137.5\ \mu\text{C}$

The capacitances add: $C = 5.5\ \mu\text{F} + C_2$

$Q = CV$

$137.5\ \mu\text{C} = (5.5\ \mu\text{F} + C_2)(10\ \text{V}) = 55\ \mu\text{C} + 10\ C_2$

$C_2 = \underline{8.25\ \mu\text{F}}$

32. $Q_1 = C_1V_1 = (4\ \mu\text{F})(1200\ \text{V}) = 4800\ \mu\text{C}$

$Q_2 = C_2V_2 = (10\ \mu\text{F})(750\ \text{V}) = 7500\ \mu\text{C}$

Total charge $= Q_1 + Q_2 = (12300)\ \mu\text{C}$

Capacitances add: $C = C_1 + C_2 = 4\ \mu\text{F} + 10\ \mu\text{F} = 14\ \mu\text{F}$

$V = Q/C = (12300\ \mu\text{C})/(14\ \mu\text{F}) = \underline{879\ \text{V}}$

Charge on each is

$Q_1 = C_1V = (4\ \mu\text{F})(879\ \text{V}) = \underline{3.51\ \text{mC}}$

$Q_2 = C_2V = (10\ \mu\text{F})(879\ \text{V}) = \underline{8.79\ \text{mC}}$

33. $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 3600 \times 10^{-12}\ \text{F} \times (300\ \text{V})^2$

$E = 162 \times 10^{-6}\ \text{J} = \underline{1.62 \times 10^{-4}\ \text{J}}$

34. (a) $C = \dfrac{\varepsilon_0 A}{d} = \dfrac{(8.85 \times 10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)(20 \times 10^{-2}\ \text{m})^2}{(2 \times 10^{-3}\ \text{m})}$

$C = 1.77 \times 10^{-10}\ \text{F} = \underline{1.8 \times 10^{-10}\ \text{F}}$

$E = q^2/2C = \dfrac{(800 \times 10^{-6}\ \text{C})^2}{(2 \times 1.77 \times 10^{-10}\ \text{F})}$

$E = \underline{1810\ \text{J}} = \underline{1.8 \times 10^3\ \text{J}}$

(b) For mica $C_{\text{mica}} = 7 \times 1.77 \times 10^{-10}\text{F}$, hence

$E = 1810/7\ \text{J} = \underline{258\ \text{J}} = 2.6 \times 10^2\ \text{J}.$

35. If distance d is doubled capacitance is halved. Before $E = Q^2/2C$. Now $E = Q^2/C$. Hence energy doubles. This is because it takes work to pull the plates apart.

36. $E = CV^2/2 = Q^2/2C = (\varepsilon_0 kA/d)V^2/2$

(a) $V \rightarrow 2V$ implies $E \rightarrow \underline{4E}$

(b) $Q \rightarrow 2Q$ implies $E \rightarrow \underline{4E}$

(c) $d \rightarrow 2d$ implies $E \rightarrow \underline{E/2}$

37. (a) $Q_1 = C_1V_1 = (3\ \mu F)(12\ V) = 36\ \mu C$
$E = C_1V_1^2/2 + C_2V_2^2/2 = (3\ \mu F)(12\ V)^2/2 + (5\ \mu F)(OV)^2/2 = \underline{216\ \mu J}$

(b) $C_{TOT} = 3\ \mu F + 5\ \mu F = 8\ \mu F$
$V = Q/C = (36\ \mu C)/(8\ \mu F) = 4.5\ V$
$E = C_{TOT}\ V^2/2 = (8\ \mu F)(4.5\ V)^2/2 = \underline{81\ \mu J}$

(c) $\Delta E = 81\ \mu J - 216\ \mu J = \underline{-135\ \mu J}$

(d) Energy is conserved only because there is 135 μJ of heat generated by the movement of the charges. Yes.

38. Use Eq 17–9. Energy density $= \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}(8.85 \times 10^{-12} C^2/N \cdot m^2)(150\ \frac{V}{m})^2 = \underline{9.96 \times 10^{-8}\ J}$.

39. (a) $\Delta E = Q\Delta V = (3C)(8.5 \times 10^6\ V) = \underline{2.55 \times 10^7\ J}$.

(b) $m = \frac{\Delta Q}{c\Delta T} = \frac{2.55 \times 10^9\ J}{4180\ J/kg^\circ C \times 100^\circ C} = \underline{61.0\ kg}$.

40. $KE = (3/2)kT = (3/2)(1.38 \times 10^{-23}\ J/K)(273^\circ K)/(1.60 \times 10^{-19}\ J/eV) = \underline{3.53 \times 10^{-2}\ eV}$.

41. $mg = EQ = \frac{-\Delta V}{\Delta d}\ Q$.

Hence $\Delta V = \frac{(9.11 \times 10^{-31}\ kg)(9.8\ m/s^2)(0.25\ m)}{1.6 \times 10^{-19}\ C} = \underline{1.39 \times 10^{-11}\ V}$, i.e. very small.

nergy stored in a capacitor is $\frac{Q^2}{2C}$

Work done = final energy − initial energy.

$$8\text{J} = \frac{(Q + 3 \times 10^{-3}\ \text{C})^2 - Q^2}{2 \times 6 \times 10^{-6}}$$

Solving,
$Q = \underline{1.45 \times 10^{-2}\ \text{C}}$

43. $PE = QV = (9 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(26)(1.6 \times 10^{-19}\ \text{C})^2/(4.0 \times 10^{-15}\ \text{m}) = \underline{9.36 \times 10^6\ \text{eV}}$.
So 9.36 MV required.

44. (a) 20 keV, since charges and potential differences are the same.

(b) $m_e v_e^2/2 = m_p v_p^2/2$.

$v_p = v_e(m_e/m_p)^{\frac{1}{2}}$
$v_p/v_e = \underline{42.8}$.

45. Before the mica, $Q = CV = 9000 \times 10^{-12}\ \text{F} \times 12\ \text{V} = 84000$ PC
After mica, $C = 49000$ PF, Q is now = 588000 PC
thus, 504000 PC or 5.04×10^{-7} C flows from battery.

46. $Q = CV = \frac{\varepsilon_0 AV}{d} = (8.85 \times 10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2)(20 \times 10^{-4}\ \text{m}^2)(3 \times 10^6\ \text{V/m}) = \underline{5.31 \times 10^{-8}\ \text{C}}$.

47. (a) The point is beyond the $-2\ \mu$C charge a distance x such that $\frac{3}{(0.02 + x)^2} - \frac{2}{x^2} = 0$
i.e. $x = 0.089$ m = $\underline{8.9\text{ cm from } -2\ \mu\text{C}}$.

(b) Point is in between distance x from $-2\ \mu$C charge: $\frac{3}{0.02 - x} - \frac{2}{x} = 0$
$x = 0.008$ m = $\underline{8\text{ mm from } -2\ \mu\text{C}}$.

48. Length of median $= \sqrt{L^2 - \frac{L^2}{4}} = \frac{\sqrt{3}}{2} L$

$$V_A = \frac{-k3Q}{L/2} - kQ/\left[\frac{\sqrt{3}}{2} L\right] + \frac{kQ}{L/2} = \frac{-4kQ}{L} - \frac{2kQ}{\sqrt{3}L} = -\left[\frac{4\sqrt{3}+2}{\sqrt{3}L}\right]kQ = \underline{5.15\frac{kQ}{L}}$$

$$\text{(b) } V_B = k\frac{(-3Q)}{(\sqrt{3}/2)L} + \frac{kQ}{L/2} + \frac{k(-Q)}{L/2} = -2\sqrt{3}\frac{kQ}{L} = \underline{3.46\frac{kQ}{L}}$$

$$\text{(c) } V_C = \frac{k(-Q)}{L/2} + \frac{k(-3Q)}{L/2} + \frac{kQ}{(\sqrt{3}/2)L} = \left[-8 + \frac{2}{\sqrt{3}}\right]\frac{kQ}{L} = \underline{-6.85\frac{kQ}{L}}$$

49. They will share the charge. $Q_0 = Q_1 + Q_2$. And have a common voltage. $V = Q_1/C_1 = Q_2/C_2$. Hence $Q_1 = \underline{Q_0/[1 + C_2/C_1]}$ and $Q_2 = \underline{Q_0[1 + C_1/C_2]}$.

$V_1 = \underline{Q_0/(C_1 + C_2) = V_2}$.

50. $$v_x = \sqrt{\frac{2E}{m}} = \sqrt{\frac{(2)(15{,}000\text{ V})(1.6\times10^{-19}\text{ C})}{9.11\times10^{-31}\text{ kg}}} = 7.26\times10^7\text{ m/s}$$

Time between plates, $t = \frac{d}{v_x} = \frac{0.05\text{ m}}{7.26\times10^7\text{ m/s}} = 6.90\times10^{-10}\text{ s}$

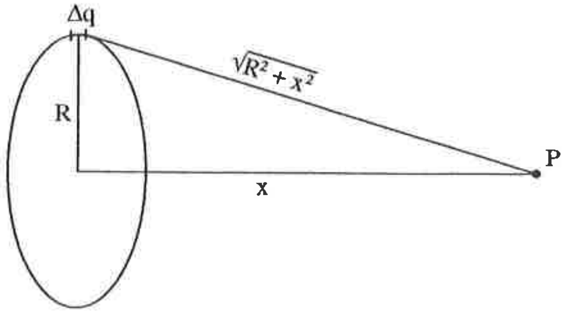
Acceleration vertically is $\frac{F}{m} = \frac{Q\Delta V}{m\Delta d}$

$$a = \frac{(1.6\times10^{-19}\text{ C})(250\text{ V})}{(9.11\times10^{-31}\text{ kg})(0.012\text{ m})} = 3.66\times10^{15}\text{ m/s}^2$$

$v_y = at = (3.66\times10^{15}\text{ m/s}^2)(6.90\times10^{-10}\text{ s}) = 2.53\times10^6\text{ m/s}$

$\theta = \tan^{-1}\left[\frac{v_y}{v_x}\right] = \underline{1.99°}$

51.



Potential at P due to $\Delta q = \dfrac{\Delta q}{4\pi\varepsilon_0\sqrt{R^2 + x^2}}$ since potential is a scalar. The potential due to the entire ring is simply $\dfrac{\Sigma\Delta q}{4\pi\varepsilon_0\sqrt{R^2 + x^2}}$.

$$V = \frac{Q}{4\pi\varepsilon_0\sqrt{R^2 + x^2}}.$$

Chapter 18

1. $Q = It = (4.5\ \text{A})(7\ \text{h})(3600\ \text{s/h}) = \underline{1.1 \times 10^5\ \text{C}}$.

2. $N = Q/e = \dfrac{(1\ \text{C/s})(1\ \text{s})}{1.6 \times 10^{-19}\ \text{C}} = \underline{6.25 \times 10^{18}}$

3. $I = \dfrac{Q}{t} = \dfrac{(1000)(1.6 \times 10^{-19}\ \text{C})}{4 \times 10^{-6}\ \text{s}} = \underline{4 \times 10^{-11}\ \text{A}}$

4. $V = IR = (0.15\ \text{A})(3000\ \Omega) = \underline{450\ \text{V}}$

5. $R = \dfrac{V}{I} = \dfrac{120\ \text{V}}{3.5\ \text{A}} = \underline{34.3\ \Omega} = \underline{34\ \Omega}$

6. (a) Since $V = IR$, if R stays constant, current will drop 10% as well, to $\underline{2.70\ \text{A}}$.

   (b) $R = \dfrac{120\ \text{V}}{3\ \text{A}} \times 0.9 = 36\ \Omega$

   $I = \dfrac{V}{R} = \dfrac{120\ \text{V}}{36\ \Omega} = \underline{3.33\ \text{A}}$

7. Number $= \dfrac{Q}{e} = \dfrac{It}{e} = \dfrac{Vt}{Re} = \dfrac{(1.5\ V)(60\ \text{s})}{(1.2\ \Omega)(1.6 \times 10^{-19}\ \text{C})} = \underline{4.69 \times 10^{20}}$

8. $V = IR = (1500\ \text{A})(1.8 \times 10^{-5}\ \Omega/\text{m})(0.03\ \text{m}) = \underline{8.1 \times 10^{-4}\ \text{V}}$

9. $I = Q/t = e\rho vA$. Hence $v = (1\ \text{A})/(1.6 \times 10^{-19}\ \text{C})/(10^{29}/\text{m}^3)/(\pi \times 10^{-6}\ \text{m}^2) = \underline{1.99 \times 10^{-5}\ \text{m/s}}$. We have used vA as the volume swept out in a second. We have also worked out the averag velocity not speed.

10. $R = \dfrac{\rho \ell}{A} = \dfrac{(1.68 \times 10^{-8}\ \Omega \cdot \text{m})(3\ \text{m})}{\pi(0.75 \times 10^{-3})^2} = 2.85 \times 10^{-2}\ \Omega$